

REMARKS

This application contains claims 1-50. Claims 1, 35, 47, 48 and 50 are hereby amended. No new matter has been introduced. Reconsideration is respectfully requested.

Claims 1-3, 6-15, 18-26, 29-37 and 40-50 were rejected under 35 U.S.C. 103(a) over Janik (U.S. Patent 6,711,232) in view of Hossain et al. (U.S. Patent 6,005,915). Applicant has amended claims 1, 35, 48 and 50 in order to clarify the distinction of the present invention over the cited art. Applicant respectfully traverses the rejection of claims 14, 15, 18-26, 29-34, 47 and 49. Claim 47 has been amended to correct a typographical error.

Janik describes apparatus for X-ray reflectivity measurement, in which an X-ray reflector directs X-rays from an X-ray source onto a target spot (abstract). A receptor receives the X-rays reflected from the target spot and provides angular and intensity information to an analyzer (col. 6, lines 56-65). Janik states explicitly that the X-rays are monochromatic: The X-ray source itself preferably emits copper Ka X-rays (col. 3, line 53), i.e., a specific, well-known monochromatic X-ray emission line at 8.05 keV. Furthermore, the reflector that focuses the X-rays onto the target spot is itself a monochromator (col. 4, lines 26-27). The use of a monochromatic beam to irradiate a sample is standard practice in the field of X-ray reflectometry, and Janik does not deviate from the standard practice in this respect. Even if Janik could be considered to disclose a polychromatic X-ray source, the beam with which he irradiates the sample is monochromatic.

Hossain describes apparatus for determining the roughness of a target surface using an X-ray fluorescence technique (abstract). An X-ray source irradiates a

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semiconductor wafer. An X-ray detector 100, positioned directly above the wafer, receives scattered primary X-ray photons and secondary (fluorescent) X-ray photons and produces an output signal proportional to the energy levels of the detected X-ray photons (col. 8, lines 25-32). In addition, an X-ray sensor 98 receives the reflected primary X-ray beam for use in controlling the position of the wafer (col. 8, lines 11-14 and 60-67). Hossain makes no suggestion that either detector 100 or sensor 98 might be movable. Each receives X-rays only at a single, fixed angle. Although the output signal of detector 100 is proportional to the photon energy, sensor 98 simply provides an intensity signal for use in controlling the sample stage position.

Claim 1 recites a method for inspection of a sample, in which the sample is irradiated with a polychromatic X-ray beam. One or more sensors receive X-rays scattered from the sample at a plurality of angles, and generate output signals indicative of the respective photon energies. The claim has been amended to clarify that these signals are generated at each of the plurality of scattering angles (as stated in the specification, for example, on page 3, lines 12-13). In other words, the scattered X-rays are received at multiple different photon energies, over multiple different angles. The output signals from the sensors are analyzed in order to determine a scattering profile at a selected photon energy.

The combined detection of multiple different photon energies at multiple different scattering angles is neither taught nor suggested by the cited art. Janik, as noted above, detects reflected photons over a range of angles but is capable of using only a monochromatic beam, as is the accepted practice in the art of X-ray reflectometry. Hossain may use a polychromatic beam

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(col. 7, lines 52-55), but is configured to detect scattered photons at only a single angle, directly above the wafer. Neither reference teaches or suggests the multi-angle, multi-energy combination recited in claim 1.

On the contrary, Janik and Hossain each teach away from such a combination. Janik explicitly states a preference for a monochromatized beam, as noted above. Polychromatic irradiation of the sample in Janik's system could seriously compromise the accuracy of the reflectometry results. Hossain states a preference for positioning the photon energy detector directly above the wafer, in order to minimize the number of scattered primary photons received by the detector (col. 4, lines 35-47). Hossain fails to suggest that there might be any benefit in receiving fluorescent photons at multiple different angles.

Thus, claim 1, as amended, is believed to be patentable over the cited art. In view of the patentability of claim 1, dependent claims 2, 3 and 6-13 are also believed to be patentable.

Independent claim 14 recites a method for inspection of a sample that comprises irradiating the sample with a polychromatic beam comprising at least first and second X-rays having distinct photon energies. The first and second X-rays scattered from the sample are detected at a plurality of scattering angles, and the detected X-rays are analyzed so as to determine a scattering profile at both of the distinct photon energies.

As explained above in reference to claim 1, the cited references fail to teach or suggest the combined detection of multiple photon energies at multiple scattering angles, as recited in claim 14. Therefore, claim 14 is also believed to be patentable, as are claims 15 and 18-24, which depend from claim 14.

Independent claims 25, 35 and 47-50 recite apparatus

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and cluster tools that operate on principles similar to the methods of claims 1 and 14. Claims 35, 48 and 50 have been amended in like manner to claim 1. Thus, for the reasons explained above, claims 25, 35 and 47-50 are believed to be patentable over the cited art, as are claims 26, 36, 37 and 40-46, which depend from either claim 25 or claim 35.

Notwithstanding the patentability of the independent claims in this application, the dependent claims are also believed to recite independently-patentable subject matter. For example, claims 11 and 21, which respectively depend from claims 1 and 14, recite that the scattering profile of the X-rays is determined as a function of azimuthal angle in the plane of the surface of the sample. In the grounds for rejection of these claims (paragraph 10 in the Official Action), the Examiner did not relate to this limitation in any way. In fact, both Janik and Hossain are concerned only with scattering (or reflection) as it relates to elevation angle, away from the plane of the surface of the sample. Neither of the cited references makes any mention or suggestion of azimuthal angles in the plane of the surface. Thus, dependent claims 11 and 21 are independently patentable over the cited art, as are the corresponding dependent apparatus claims 31 and 44.

Similar arguments may be made with respect to other dependent claims, but for the sake of brevity, Applicant will refrain from arguing their patentability at present.

Claims 4, 5, 16, 17, 27, 28, 38 and 39 were objected to for depending from a rejected base claim, but were deemed to recite allowable subject matter. In view of the amendments and remarks presented above as to the patentability of the independent claims in this application, Applicant believes that this objection should now be withdrawn.

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CONCLUSION

Applicant believes the amendments and remarks presented hereinabove to be fully responsive to all of the objections and grounds of rejection raised by the Examiner. In view of these amendments and remarks, Applicant respectfully submits that all of the claims in the present application are in order for allowance. Notice to this effect is hereby requested.

AUTHORIZATION

The Commissioner is hereby authorized to charge any additional fees which may be required for consideration of this Amendment to Deposit Account No. 13-4503, Order No. 4350-4004. A DUPLICATE OF THIS DOCUMENT IS ATTACHED.


In the event that an extension of time is required, or which may be required in addition to that requested in a petition for an extension of time, the Commissioner is requested to grant a petition for that extension of time which is required to make this response timely and is hereby authorized to charge any fee for such an extension of time or credit any overpayment for an extension of time to Deposit Account No. 13-4503, Order No. 4350-4004. A DUPLICATE OF THIS DOCUMENT IS ATTACHED.

Respectfully submitted,

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